Total Maximum Daily Load of Sediment in the Non-tidal South River Watershed, Anne Arundel County, Maryland

FINAL

MARYLAND

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Submitted to:

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1650 Arch Street
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September 2017

EPA Submittal Date: June 9, 2017
EPA Approval Date: September 28, 2017

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List of Abbreviations

AFO	Animal Feeding Operations
BIBI	Benthic Index of Biotic Integrity
BIP	Buffer Incentive Program
BMP	Best Management Practices
BSID	Biological Stressor Identification
CAFOs	Concentrated Animal Feeding Operations
CBLCD	Chesapeake Bay Land-Cover Dataset
CBP	Chesapeake Bay Program
CBP P4.3	Chesapeake Bay Program Model Phase 4.3
CBP P5.3.2	Chesapeake Bay Program Model Phase 5.3.2
CCAP	Coastal Change Analysis Program
cfs	Cubic Feet per Second
COMAR	Code of Maryland Regulations
CV	Coefficient of Variation
CWA	Clean Water Act
DI	Diversity Index
EOF	Edge-of-Field
EOS	Edge-of-Stream
EPT	*Ephemeroptera*, *Plecoptera*, and *Trichoptera*
ESD	Environmental Site Design
FIBI	Fish Index of Biologic Integrity
GIS	Geographic Information System
HBI	Hilsenhoff Biotic Index
HSPF	Hydrological Simulation Program Fortran
IBI	Index of Biotic Integrity
LA	Load Allocation
m	Meter
m^3/yr	Meters cubed per year
MACS	Maryland Agricultural Water Quality Cost-Share Program
MAL	Minimum Allowable IBI Limit
MBSS	Maryland Biological Stream Survey
MDA	Maryland Department of Agriculture
MDDNR	Maryland Department of Natural Resources
MDE	Maryland Department of the Environment
MDL	Maximum Daily Load
MDP	Maryland Department of Planning
MGD	Millions of Gallons per Day
mg/l	Milligrams per liter
MGS	Maryland Geological Survey
MOS	Margin of Safety
MRLC	Multi-Resolution Land Characteristics

MS4	Municipal Separate Storm Sewer System
NLCD	National Land-Cover Dataset
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
NRCS	Natural Resource Conservation Service
NRI	Natural Resources Inventory
PSU	Primary Sampling Unit
SCS	Soil Conservation Service
SDF	Sediment Delivery Factor
SHA	State Highway Administration
TMDL	Total Maximum Daily Load
ton/acre/yr	Tons per acre per year
ton/day	Tons per day
ton/yr	Tons per year
TSD	Technical Support Document
TSS	Total Suspended Solids
USDA	United States Department of Agriculture
USEPA	U.S. Environmental Protection Agency
USGS	United States Geological Survey
WIP	Watershed Implementation Plan
WLA	Waste Load Allocation
WQA	Water Quality Analysis
WQLS	Water Quality Limited Segment

EXECUTIVE SUMMARY

Section 303(d) of the federal Clean Water Act (CWA) and the U.S. Environmental Protection Agency's (USEPA) implementing regulations direct each state to identify and list waters, known as water quality limited segments (WQLSs), in which current required controls of a specified substance are inadequate to achieve water quality standards. For each WQLS, the State is required to either establish a TMDL of the specified substance that the waterbody can receive without violating water quality standards, or demonstrate that water quality standards are being met (CFR 2012b). This document, upon approval by USEPA, establishes a Total Maximum Daily Load (TMDL) for sediment/total suspended solids (TSS) in the non-tidal Maryland 8-Digit South River watershed (2014 *Integrated Report of Surface Water Quality in Maryland* Assessment Unit ID: MD-02131003). In this TMDL, the terms TSS and sediment may be used interchangeably.

The Maryland Department of the Environment (MDE) identified the waters of the South River watershed on the State's 2014 Integrated Report as impaired by multiple pollutants (MDE 2014a). The South River is associated with two assessment units in Maryland's Integrated Report: a non-tidal 8-digit watershed (02131003) and an estuary portion (Chesapeake Bay segment South River Mesohaline). Table ES-1 identifies Integrated Report listings associated with this watershed (MDE 2014a). A data solicitation for TSS/sediment was conducted by MDE in August 2016 and all readily available data have been considered.

The Maryland Surface Water Use Designation in the Code of Maryland Regulations (COMAR) for the South River watershed's nontidal tributaries are designated as Use Class I - *water contact recreation, and protection of nontidal warmwater aquatic life.* Tidal tributaries and the South River mainstem are designated Use Class II - *support of estuarine and marine aquatic life and shellfish harvesting* (COMAR 2016a, b, c).

The South River watershed was originally listed for biological impairment on the 2002 Integrated Report. The listing was based on the biological assessment methodology, which uses aquatic health scores, consisting of the Benthic Index of Biotic Integrity (BIBI) and Fish Index of Biotic Integrity (FIBI). These indices indicated that the biological metrics for the watershed exhibit a significant negative deviation from reference conditions (MDE 2002a).

Table ES-1: South River Integrated Report Listings

Watershed	Basin Code	Tidal/Non-tidal	Subwatershed	Designated Use Class	Year Listed	Identified Pollutant	Listing Category
South River	02131003	Non-tidal		I - Aquatic Life and Wildlife	2014	TSS	5
						Chlorides	
						Lack of Riparian Buffer	4c
			Broad Creek		-	Zinc	2
						Copper	
						Lead	
						Low pH	
South River Mesohaline	SOUMH	Tidal		II - Seasonal Migratory Fish Spawning and Nursery Subcategory	2012	TN	4a
						TP	
				Open Water Fish and Shellfish	1996	TN	
						TP	
				Seasonal Shallow Water – Submerged Aquatic Vegetation	1996	TSS	
				Seasonal Deep-Water Fish and Shellfish Subcategory	2012	TN	
						TP	
				Aquatic Life and Wildlife	2008	Impacts to Biological Communities	5
				Fishing	2002	PCB	
					-	Mercury	2
			Ramsey Lake	Shellfishing	1996	Fecal Coliform	4a
			Selby Bay				
			Duvall Creek				
			Annapolis Landing Beach	Water Contact Sports	-	Enterococcus	2

Note:

- Category 2 indicates the waterbody is meeting water quality standards for the identified substance
- Category 3 indicates insufficient data to make a listing category determination
- Category 4a indicates a TMDL has been completed and approved by EPA
- Category 4c indicates the cause of the impairment is pollution and not a pollutant
- Category 5 indicates that the waterbody is impaired and a TMDL or water quality analysis (WQA) is needed.

In order to determine what stressor or stressors are impacting aquatic life, MDE's *Biological Stressor Identification* (BSID) methodology was applied. The BSID analysis for the non-tidal South River watershed identified TSS/sediment, instream habitat, riparian habitat, inorganic pollutants (i.e. chlorides), and low pH. The TSS/sediment parameter shows a significant association with degraded biological conditions; as much as 54% of the biologically impacted stream miles in the watershed may be degraded due to poor epifaunal substrate. The instream habitat stressor group may affect up to 77% of the biologically impacted stream miles in the watershed due to marginal to poor instream habitat structure. The riparian habitat stressor group was significant in 60% of streams due to the absence of riparian buffer. High chlorides were found in 42% of biologically impaired stream miles, and low pH was found in 46% of the impaired stream miles. Additionally, the BSID identified, anthropogenic, urban, and impervious sources as those that have lead to altered habitat heterogeneity and possible elevated suspended sediment in the watershed, which are in turn the probable causes of impacts to biological communities. Further details of this analysis are presented in the 2014 document entitled, '*Watershed Report for Biological Impairment of the Non-Tidal South River Watershed in Anne Arundel County, Maryland Biological Stressor Identification Analysis Results and Interpretation*'. (MDE 2014b)

As a result of the BSID analysis, the non-tidal MD 8-digit South River watershed was listed on the 2014 Integrated Report as impaired by TSS and requiring a TMDL. The TMDL will apply only to the non-tidal portion of the watershed. For simplicity, further reference in this document to South River Watershed will refer only to the non-tidal MD 8-digit watershed.

The objective of this TMDL is to ensure that watershed sediment loads are at a level that supports the Use Class I designations for the non-tidal South River watershed. The TMDL will address water clarity problems and associated impacts to aquatic life in the South River watershed caused by high sediment and TSS concentrations.

The CWA requires TMDLs to be protective of all the designated uses applicable to a particular waterbody. The primary focus of this TMDL is the designated use of protection of aquatic life because the Integrated Report listing was based on a biological assessment of the watershed. However, the required reductions are expected to protect all designated uses of the watershed, including water contact recreation. It is understood that aquatic life is more sensitive to sediment impacts than recreation because aquatic life impacts result from continuous exposure than can affect respiration and propagation. Recreation, on the other hand, is sporadic and often avoided during times when sediment concentrations are likely to be highest (e.g. rainstorms). Sediment also poses no human health risk due to dermal contact or minimal ingestion that could occur during recreation.

Currently in Maryland, there are no specific numeric criteria that quantify the impact of sediment on the aquatic life of non-tidal stream systems. In order to quantify the impact of sediment on the aquatic life of non-tidal stream systems, a reference watershed TMDL approach was used, which resulted in the establishment of a *sediment loading threshold* (MDE 2006). This threshold is based on a detailed analysis of sediment loads from watersheds that are identified as supporting aquatic life (i.e., reference watersheds) based on Maryland's biological assessment methodology (Roth *et al*. 1998, 2000; Stribling *et al*. 1998; MDE 2014c). This threshold is then used to determine a watershed specific sediment TMDL endpoint. The resulting loads are considered the maximum allowable loads the waterbody can receive without causing any sediment related impacts to aquatic health.

In order to use a reference watershed approach, sediment loads are estimated using a watershed model. For this analysis, the Chesapeake Bay Program Phase 5.3.2 (CBP P5.3.2) watershed model was chosen and specifically, the *edge-of-stream* (EOS) land-use sediment loads were used. The CBP P5.3.2 model was appropriate for this TMDL because the spatial domain of the model segmentation aggregates to the MD 8-digit watershed scale, which is consistent with the impairment listing.

USEPA's regulations require TMDLs to take into account seasonality and critical conditions for stream flow, loading, and water quality parameters (CFR 2012b). The intent of this requirement is to ensure that the water quality of the waterbody is protected during times when it is most vulnerable. The biological monitoring data used to determine the reference watersheds reflect the impacts of stressors (i.e., sediment impacts to stream biota) over the course of time (i.e., captures the impacts of both high and low flow events). Thus, critical conditions are inherently addressed. Seasonality is captured in several components. First, it is implicitly included in biological sampling as biological communities reflect the impacts of stressors over time, as described above. Second, the Maryland Biological Stream Survey (MBSS) dataset, which serves as the primary dataset for calculating the biological metrics of the watershed (i.e., BIBI and FIBI scores), included benthic sampling in the spring and fish sampling in the summer. Moreover, the sediment loading rates used in the TMDL were determined using the CBP P5.3.2 model, which is a continuous simulation model with a simulation period 1991-2000, based on Hydrological Simulation Program Fortran (HSPF) model, thereby addressing annual changes in hydrology and capturing wet, average, and dry years.

All TMDLs need to be presented as a sum of waste load allocations (WLAs) for point sources and load allocations (LAs) for nonpoint sources generated within the assessment unit, accounting for natural background, tributary and adjacent segment loads. Furthermore, all TMDLs must include a margin of safety (MOS) to account for any lack of knowledge and uncertainty concerning the relationship between loads and water quality (CFR 2012a,b). It is proposed that the estimated variability around the reference watershed group used in this analysis already accounts for such uncertainty, and therefore the MOS is implicitly included. Because the sediment loading threshold was conservatively based on the median (50^{th} percentile) sediment loading rates from reference watersheds, Maryland has adopted an implicit MOS for sediment TMDLs.

The South River watershed total baseline sediment load is 1,982 tons per year (ton/yr). The South River watershed baseline load contribution is further subdivided into a nonpoint source baseline load (Nonpoint Source BL_{SR}) and two types of point source baseline loads: National Pollutant Discharge Elimination System (NPDES) regulated stormwater (NPDES Stormwater BL_{SR}) and regulated waste water (Waste Water BL_{SR}) (see Table ES-2).

Table ES-2: South River Watershed Baseline Sediment Loads (ton/yr)

Total Baseline Load (ton/yr)	=	Nonpoint Source BL_{SR}	+	NPDES Stormwater BL_{SR}	+	Waste Water BL_{SR}
1,982	=	537	+	1,444	+	1

The South River Watershed average annual TMDL of TSS is 1,546 ton/yr (a 22% reduction from the baseline load). The South River TMDL contribution is further subdivided into point and nonpoint source allocations and is comprised of a load allocation (LA_{SR}) of 495 ton/yr, an NPDES Stormwater Waste Load Allocation (NPDES Stormwater WLA_{SR}) of 1,050 ton/yr, and a Water Waste Load Allocation (Waste Water WLA_{SR}) of 1 ton/yr (see Table ES-3).

Table ES-3: South River Watershed Average Annual TMDL of Sediment/TSS (ton/yr)

TMDL (ton/yr)	=	LA_{SR}	+	NPDES Stormwater WLA_{SR}	+	Waste Water WLA_{SR}	+	MOS
1,546	=	495	+	1,050	+	1	+	Implicit

Table ES-4: South River Watershed Baseline Load, TMDL, and Total Reduction Percentage

Baseline Load (ton/yr)	TMDL (ton/yr)	Total Reduction (%)
1,982	1,546	22

In addition to the TMDL value, a Maximum Daily Load (MDL) is also presented in this document. The calculation of the MDL, which is derived from the TMDL average annual loads, is explained in Appendix B and presented in Table B-1.

While this TMDL establishes a sediment loading target for the watershed, watershed managers and other stakeholders should always remain cognizant that the endpoint of this TMDL, and hence the definition of its successful implementation, is based on in-stream biological health. Load reductions are critical to tracking this effort, since the TMDL target is defined as the point where sediment loads match those seen in reference watersheds, but the watershed cannot be delisted or classified as meeting water quality standards until it is demonstrated that the biological health of the stream system is no longer impaired by sediment. In planning any implementation efforts related to this TMDL, careful consideration should be given both to the sediment load reductions, and to the direct potential impacts on biological communities.

Section 303(d) of the CWA and current USEPA regulations require reasonable assurance that the TMDL can and will be implemented. Once USEPA has approved this TMDL and it is known what measures must be taken to reduce pollution levels, implementation of best management practices (BMPs) is expected to take place. The South River Sediment TMDL is expected to be implemented as part of a staged process. MDE intends for the required reductions to be implemented in an iterative process that first addresses those sources with the largest impact to water quality, with consideration given to cost of implementation.

Implementation of the non-tidal South River Watershed Sediment TMDL is expected to occur in parallel with implementation efforts to meet sediment target loads consistent with the 2010 Chesapeake Bay TMDLs. The Chesapeake Bay TMDLs were established by USEPA (USEPA 2010a) and are scheduled for full implementation by 2025. The Bay TMDLs require reductions of nitrogen, phosphorus, and sediment loads throughout the Bay watershed to meet water quality standards that protect the designated uses in the Bay and its tidal tributaries.

In addition, MDE published the Final Determination to Issue Stormwater Permit to Anne Arundel County in February 2014. The permit states, *"By regulation at 40 CFR §122.44, BMPs and programs implemented pursuant to this permit must be consistent with applicable WLAs developed under [US]EPA approved TMDLs."* For TMDLs approved after the permit, implementation plans are due within one year of USEPA approval of the TMDL. Many of the practices which are described in the permittees' stormwater WLA implementation plans may also be used by the permittees as retrofits for meeting their impervious area restoration requirements.

This TMDL will ensure that watershed sediment loads are at a level to support the designated uses for the South River watershed, and more specifically, at a level to support aquatic life. The TMDL, however, will not completely resolve the impairment to biological communities within the watershed. Since the BSID watershed analysis identifies other possible stressors impacting the biological conditions (e.g. chlorides), an additional TMDL or TMDLs may be needed to fully address the impacts to biological communities.

Many of the implementation actions to address sediment could concurrently address the other stressors identified in the BSID report. For example, a stream restoration project that reduces sediment loads could improve epifaunal substrate and in-stream habitat. Since biological improvements will likely only be seen when multiple structural and pollutant stressors are addressed, watershed managers developing plans to address sediment should consider the effect of restoration projects on other stressors. Where possible, preference should be given to designs that address multiple stressors.

1.0 INTRODUCTION

Section 303(d) of the federal Clean Water Act (CWA) and the U.S. Environmental Protection Agency's (USEPA) implementing regulations direct each state to identify and list waters, known as water quality limited segments (WQLSs), in which current required controls of a specified substance are inadequate to achieve water quality standards. For each WQLS, the State is required to either establish a TMDL of the specified substance that the waterbody can receive without violating water quality standards, or demonstrate that water quality standards are being met (CFR 2012b). This document, upon approval by the USEPA, establishes a Total Maximum Daily Load (TMDL) for sediment in the non-tidal Maryland 8-Digit South River watershed (2014 *Integrated Report of Surface Water Quality in Maryland* Assessment Unit ID: MD-02131003). In this TMDL, the terms TSS and sediment may be used interchangeably.

TMDLs are established to determine the pollutant load reductions needed to achieve and maintain water quality standards. A water quality standard is the combination of a designated use for a particular body of water and the water quality criteria designed to protect that use. Designated uses include activities such as swimming, drinking water supply, protection of aquatic life, and shellfish propagation and harvest. Water quality criteria consist of narrative statements and numeric values designed to protect the designated uses. Criteria may differ among waters with different designated uses.

The Maryland Department of the Environment (MDE) identified the waters of the South River watershed on the State's 2014 Integrated Report as impaired by multiple pollutants (MDE 2014a). The South River watershed is associated with two assessment units in Maryland's Integrated Report: a non-tidal 8-digit watershed (02131003) and an estuary portion (Chesapeake Bay segment: South River Mesohaline). Table 1 identifies the impairment listings associated with this watershed (MDE 2014a).

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Footnote:
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The South River watershed was originally listed for biological impairment on the 2002 Integrated Report. The listing was based on the biological assessment methodology, which uses aquatic health scores, consisting of the Benthic Index of Biotic Integrity (BIBI) and Fish Index of Biotic Integrity (FIBI). These indices indicated that the biological metrics for the watershed exhibit a significant negative deviation from reference conditions (MDE 2002a).

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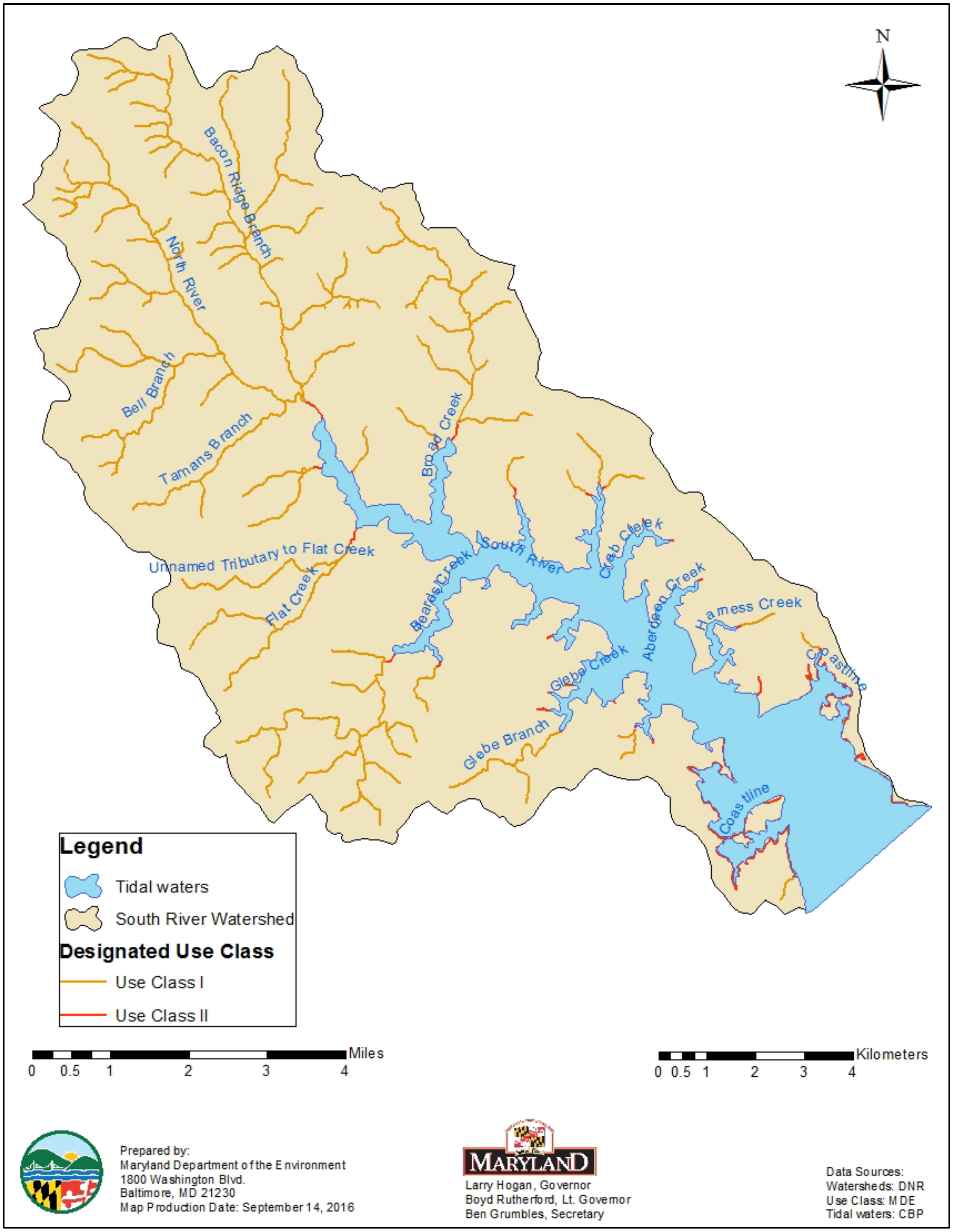

Figure 1: Designated Use Classes of the South River Watershed in Anne Arundel County, Maryland

2.0 SETTING AND WATER QUALITY DESCRIPTION

2.1 General Setting

Location

The South River watershed is located entirely within central Anne Arundel County, Maryland. The watershed is located in the Coastal Plain eco-region, identified in the Maryland Department of Natural Resources (MDDNR) Maryland Biological Stream Survey (MBSS) Index of Biological Integrity (IBI) metrics (Southerland *et al.* 2005).

According to the Chesapeake Bay Program's Phase 5.3.2 watershed model, the total drainage area of the Maryland 8-digit watershed is approximately 36,200 acres, not including water/wetlands. Approximately 300 acres of the watershed area is covered by water. The total population in the South River watershed is approximately 75,800 (US Census Bureau 2010).

There are no "high quality," or Tier II, stream segments (BIBI and FIBI aquatic life assessment scores > 4 [scale 1-5]) located within the South River watershed. Tier II segments would require the implementation of Maryland's anti-degradation policy (COMAR 2016d; MDE 2011).

Geology/Soils

The South River watershed lies entirely within the Coastal Plain geologic province of Maryland. The Coastal Plain is characterized by deep sedimentary soil complexes that support broad meandering streams (MDDNR 2009; MGS 2012; MDE 2000). The surface elevations range from sea level at the Chesapeake Bay shoreline to approximately 680 feet.

The United States Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS) classifies soils into 4 hydrologic soil groups: Group A soils have high infiltration rates and are typically deep well drained/excessively drained sands or gravels; Group B soils have moderate infiltration rates and consist of soils that are moderately deep to deep and moderately well to well drained soils, with moderately fine/coarse textures; Group C soils have slow infiltration rates with a layer that impedes downward water movement, and they primarily have moderately fine-to-fine textures; Group D soils have very slow infiltration rates consisting of clay soils with a permanently high water table that are often shallow over nearly impervious material. The South River watershed is comprised primarily of Group B soils (65.4%), Group C soils (14.8%), and Group D soils (18.1%), with a small portion of the watershed consisting of Group A soils (1.1%) (USDA 2006).

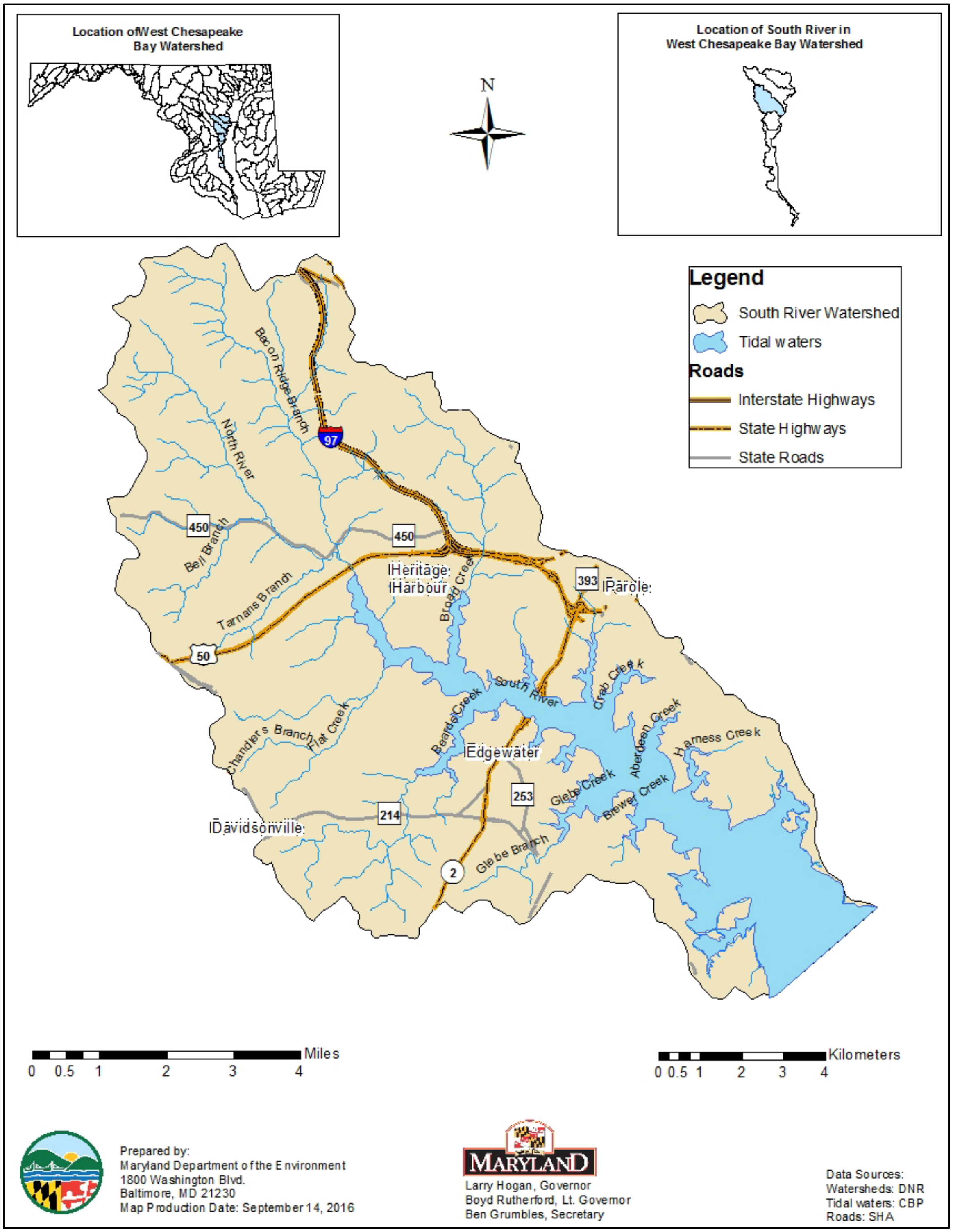

Figure 2: Location Map of the South River Watershed in Anne Arundel County, Maryland

2.1.1 Land-use

Land-use Methodology

The land-use framework used to develop this TMDL was originally developed for the Chesapeake Bay Program Phase 5.3.2 (CBP P5.3.2) Watershed Model.[1] The CBP P5.3.2 land-use was based on two distinct stages of development.

The first stage consisted of the development of the Chesapeake Bay Watershed Land-Cover Data (CBLCD) series of Geographic Information System (GIS) datasets. These datasets provide a 30-meter resolution raster representation of land-cover in the Chesapeake Bay watershed, based on sixteen Anderson Level two land-cover classes. The CBLCD basemap, representing 2001 conditions, was primarily derived from the Multi-Resolution Land Characteristics (MRLC) Consortium's National Land-Cover Data (NLCD) and the National Oceanic and Atmospheric Administration's (NOAA) Coastal Change Analysis Program's (CCAP) Land-Cover Data. By applying Cross Correlation Analysis to Landsat 5 Thematic Mapper and Landsat 7 Enhanced Thematic Mapper satellite imagery, CBLCD datasets for 1984, 1992, and 2006 were generated from the baseline 2001 dataset. The watershed model documentation, *Chesapeake Bay Phase 5.3 Community Watershed Model* (USEPA 2010b), describes the development of the CBLCD series in more detail. USGS and NOAA also developed an impervious cover dataset from Landsat satellite imagery for the CBLCD basemap, which was used to estimate the percent impervious cover associated with CBLCD developed land-cover classifications.

The second stage consisted of using ancillary information for: 1) the creation of a modified 2006 CBLCD raster dataset, and 2) the subsequent development of the CBP P5.3.2 land-use framework in tabular format. Estimates of the urban footprint in the 2006 CBLCD were extensively modified using supplemental datasets. Navteq street data (secondary and primary roads) and institutional delineations were overlaid with the 2006 CBLCD land-cover and used to reclassify underlying pixels. Certain areas adjacent to the secondary road network were also reclassified based on assumptions developed by USGS researchers, in order to capture residential development (*i.e.*, subdivisions not being picked up by the satellite in the CBLCD). In addition to spatially modifying the 2006 CBLCD, the following datasets were used to supplement the developed land cover data in the final CBP P5.3.2 land-use framework: US Census housing unit data, Maryland Department of Planning (MDP) Property View data, and estimates of impervious coefficients for rural residential properties (determined via a sampling of these properties using aerial photography). This additional information was used to estimate the extent of impervious area in roadways and residential lots. Acres of construction and extractive land-uses were determined independently using a method developed by USGS. (Claggett, Irani, and Thompson 2012). Finally, in order to develop accurate agricultural land-use acreages, the CBP P5.3.2 incorporated county level US Agricultural Census data (USDA

[1] The EPA Chesapeake Bay Program developed the first watershed model in 1982. There have been many upgrades since the first phase of this model. The CBP P5.3.2 is the latest version and it was developed to estimate flow, nutrients, and sediment loads to the Bay.

1982, 1987, 1992, 1997, 2002). The watershed model documentation, *Chesapeake Bay Phase 5.3 Community Watershed Model* (US USEPA 2010b), describes these modifications in more detail.

The result of these modifications is that CBP P5.3.2 land-use does not exist in a single GIS coverage; instead, it is only available in a tabular format. The CBP P5.3.2 watershed model is comprised of 30 land-uses. The land-uses are divided into 13 classes with distinct sediment erosion rates. Table 2 lists the CBP P5.3.2 generalized land-uses, detailed land-uses, which are classified by their sediment erosion rates, and the acres of each land-use in the South River watershed. The land-use acreage used to inform this TMDL is based on the CBP P5.3.2 2009 Progress Scenario.

South River Watershed Land-Use Distribution

The land-use distribution of the South River watershed consists primarily of forest (56.6%) and urban land (36.5%). A detailed summary of the watershed land-use areas is presented in Table 2, and a land-use map is provided in Figure 3.

Table 2: Land-Use Percentage Distribution for the South River Watershed

General Land Use	Detailed Land-Use	Area (Acres)	Percent of total (%)	Grouped Percent of Total
Forest	Forest	20,475	56.1%	56.7%
	Harvested Forest	206	0.6%	
AFOs	Animal Feeding Operations	4	0.0%	0.0%
Pasture	Pasture	525	1.4%	1.4%
Crop	Crop	1,648	4.5%	4.5%
Nursery	Nursery	9	0.0%	0.0%
Regulated Urban	Construction	223	0.6%	36.5%
	Developed	13,117	35.9%	
Water	Water	306	0.8%	0.8%
Total		**36,514**	**100.0%**	**100.0%**

Note: Individual values may not add to total load due to rounding.

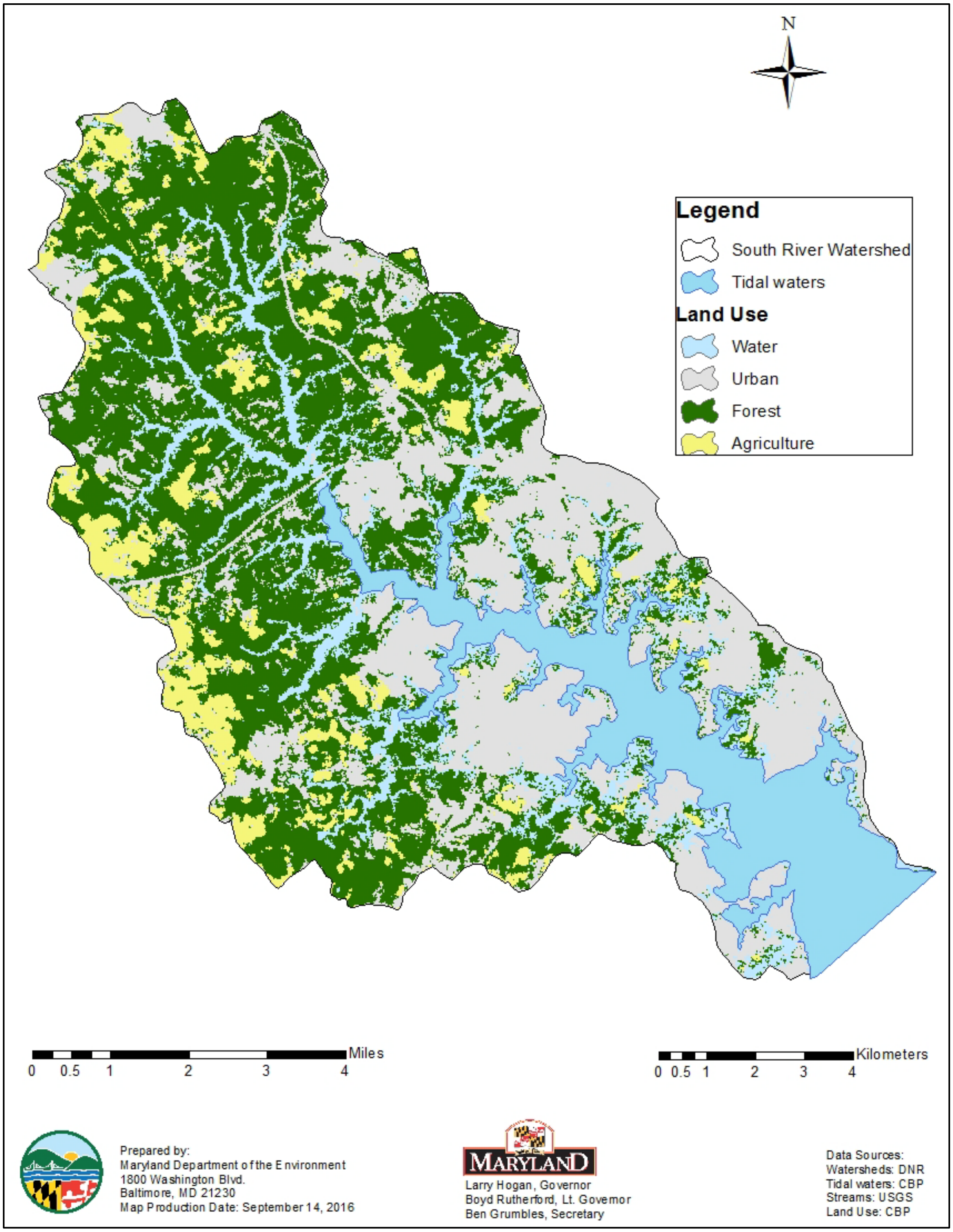

Figure 3: Land-use of the South River Watershed

2.2 Source Assessment

The South River watershed total baseline sediment load consists of nonpoint sources loads, and point source loads which can be further divided into National Pollutant Discharge Elimination System (NPDES) Stormwater loads, and Waste Water loads. This section summarizes the methods used to derive each of these distinct source categories.

2.2.1 Nonpoint Source Assessment

In this document, the nonpoint source loads account for all sediment loads not covered under a NPDES permit within the South River watershed. In general, these are rainfall driven land-use based loads from agricultural and forested lands. This section provides the background and methods for determining the nonpoint source baseline loads generated within the South River watershed (Nonpoint Source BL_{SR}).

General Load Estimation Methodology

Nonpoint source sediment loads generated within the South River watershed are estimated based on the *edge-of-stream (EOS)* loads from the CBP P5.3.2 watershed model 2009 Progress Scenario. Within the CBP P5.3.2 watershed model, EOS sediment loads are calculated based on the fact that not all of the *edge-of-field* (EOF) sediment load is delivered to the stream or river (some of it is stored on fields down slope, at the foot of hillsides, or in smaller rivers or streams that are not represented in the model). To calculate the actual EOS loads, a *sediment delivery factor (SDF)* (the ratio of sediment reaching a basin outlet compared to the total erosion within the basin) is used. Details of the methods used to calculate sediment load have been documented in the report entitled *Chesapeake Bay Phase 5 Community Watershed Model* (USEPA 2010b). A summary of the methodology is presented in the following sections.

Edge-of-Field Target Erosion Rate Methodology

Edge-of-field erosion can be defined as erosion or sediment loss from any particular land surface. EOF target erosion rates are the values used in the calibration of the CBP model, based on literature values. EOF target erosion rates for agricultural land-uses and forested land-use were based on erosion rates determined by the Natural Resource Inventory (NRI). NRI is a statistical survey of land-use and natural resource conditions conducted by the Natural Resources Conservation Service (NRCS) (USDA 2006). The sampling methodology is explained by Nusser and Goebel (1997).

Estimates of average annual erosion rates for pasture and cropland are available on a county basis at five-year intervals, starting in 1982. Erosion rates for forested land-uses are not available on a county basis from NRI; however, for the purpose of the Chesapeake Bay Program Phase 4.3 (CBP P4.3) watershed model, NRI calculated average annual erosion rates for forested land-use on a watershed basis. These rates are still being used as targets in the CBP P5.3.2 model.

The average value of the 1982 and 1987 surveys was used as the basis for EOF target rates for pasture and cropland. Rates for urban pervious, urban impervious, extractive, and barren land were based on a combination of best professional judgment, literature analysis, and regression analysis. The EOF erosion rates do not reflect best management practices (BMPs) or other soil conservation policies introduced in the wake of the effort to restore the Chesapeake Bay. To compensate for this, BMPs are applied to the modeled EOS loads in the CBP P5.3.2 2009 Progress Scenario. BMP data, representing BMPs in place in 2009, was collected by the Chesapeake Bay Program (CBP), and TSS reduction efficiencies have been estimated by CBP for specific types of BMPs based on peer reviewed studies, data collected by local jurisdictions, and an analysis of available literature values. For further details regarding EOF erosion rates, please see Section 9.2.1 of the *Chesapeake Bay Phase 5 Community Watershed Model* (USEPA 2010b). Table 3 lists EOF erosion rates specific to Anne Arundel County, where the South River watershed is located.

Table 3: Anne Arundel County Target EOF TSS Loading Rates (ton/acre/yr) by Land-Use

Land-use	Data Source	Target EOF TSS loading rate (ton/acre/yr)
Forest	NRI (1987)	0.29
Harvested Forest	Literature values	3
Nursery	Equivalent to conventional till	10.06
Pasture	NRI average (1982-1987)	0.47
Animal Feeding Operations	NRI pasture average (1982-1987) multiplied by 9	4.2
Hay	Adjusted NRI average (1982-1987)	2.58
Conventional Till	Adjusted NRI average (1982 – 1987)	10.06
Conservation Till	Adjusted NRI average (1982 – 1987)	6.04
Pervious Urban	Regression Analysis	0.74
Extractive	Literature values/best professional judgment	10
Barren (Construction)	Literature values	12.0
Impervious Urban	Regression Analysis	5.18

Edge-of-Stream Sediment Loads

A portion of EOF sediment load is delivered to the stream or river. The remaining eroded sediment is stored on fields downslope, at the foot of hillsides, or in smaller rivers or streams that are unrepresented in the model. EOS sediment loads are the loads that enter the modeled river reaches. Modeled river reaches are those with discharges of 100 cubic feet per second (cfs) or greater. (Exceptions were made for some river reaches that had useful monitoring data but were less than 100 cfs.) EOS sediment loads represent not only the erosion from the land but all of the intervening processes of deposition on hillsides and sediment transport through smaller rivers and streams that are not represented in the Phase 5.3 Model. The influence of the sum of the processes is contained in the estimated sediment delivery factor (SDF), which represents the ratio between sediment transported at a watershed outlet and erosion generated in the watershed. The EOS load for a reach is, therefore, the integration of sediment load scour, transport, storage, and fate from all smaller watersheds and streams unrepresented in the model. (USEPA 2010b)

The formula for the EOS load calculation within the CBP P5.3.2 watershed model is as follows:

$$\sum_{i}^{n} EOS = Acres_i * EOF_i * SDF_i \qquad \text{(Equation 2.1)}$$

where:
- n = number of land-use classifications
- i = land-use classification
- EOS = Edge of stream load, tons per year (ton/yr)
- Acres = acreage for land-use i
- EOF = Edge-of-field erosion rate for land-use i, ton/acre/yr
- SDF = sediment delivery factor for land-use i

2.2.2 Point Source Assessment

A list of active permitted point sources that contribute to the sediment load in the South River watershed was compiled using best available resources. The types of permits identified include individual municipal permits, NPDES stormwater permits, individual and general MS4 permits, general industrial stormwater permits, and the general permit for stormwater discharges from construction sites. The permits can be grouped into two categories: waste water and stormwater. The waste water category includes those loads generated by continuous discharge sources whose permits have TSS limits. Wastewater permits that do not meet these conditions are considered *de minimis* in terms of the total sediment load. The stormwater category includes all NPDES regulated stormwater discharges, including construction. The technical memorandum to this document, entitled *Point Sources of Sediment in the Non-Tidal South River Watershed,* identifies all the waste water permits and NPDES regulated stormwater discharges that contribute to the sediment load in the South River watershed.

The baseline sediment loads for the waste water permits (Waste Water BL_{SR}) are calculated based on their permitted TSS limits (average monthly or weekly concentration values) and corresponding flow information. The stormwater permits identified throughout the South River watershed do not include TSS limits. In the absence of TSS limits, the NPDES regulated stormwater baseline load (NPDES Stormwater BL_{SR}) is calculated using the CBP P5.3.2 Progress Scenario urban land-use EOS loads (as per Equation 2.1), similar to the approach for NPS loads outlined in Section 2.1. The technical memorandum to this document, entitled *Point Sources of Sediment in the Non-Tidal South River Watershed*, provides detailed information regarding the calculation of the South River watershed Waste Water BL_{SR} and NPDES Stormwater BL_{SR}.

2.2.3 Summary of Baseline Loads

Table 4 summarizes the South River Watershed baseline sediment load, reported in ton/yr and presented in terms of Nonpoint Source Baseline Loads and NPDES Stormwater and Waste Water Baseline Loads.

Table 4: South River Watershed Baseline Sediment Loads (ton/yr)

Total Baseline Load (ton/yr)	=	**Nonpoint Source BL_{SR}**	+	**NPDES Stormwater BL_{SR}**	+	**Waste Water BL_{SR}**
1,982	=	537	+	1,444	+	1

Table 5 presents a breakdown of South River Watershed Total Baseline Sediment Load, detailing loads per land-use or other source category.

Table 5: Detailed Baseline Sediment Loads Within the South River Watershed

General Land Use	Detailed Land-Use	Tons	Percent (%)	Grouped Percent of Total
Forest	Forest	222	11.2%	12.0%
	Harvested Forest	16	0.8%	
Pasture	Pasture	9	0.5%	0.5%
Crop	Crop	288	14.5%	14.5%
Nursery	Nursery	1	0.1%	0.1%
Regulated Urban	Construction	157	7.9%	72.8%
	Developed	1,287	64.9%	
Point Sources				0.1%
	Municipal Point Sources	1	0.1%	
Total		**1,982**	**100.0%**	**100.0%**

Footnote:

- Individual values may not add to total load due to rounding.
- Baseline sediment load values are based on CBP 5.3.2 2009 Progress Scenario

2.3 Water Quality Characterization

The non-tidal South River watershed was identified on Maryland's 2014 Integrated Report as having multiple impairments. To refine the listing for impacts to biological communities, Maryland conducted a stressor identification analysis. Details of this analysis are presented below and in the document entitled, *Watershed Report for Biological Impairment of the South River Watershed in Anne Arundel County, Maryland Biological Stressor Identification Analysis Results and Interpretation*.

Currently in Maryland, there are no specific numeric criteria for suspended sediments. Therefore, to determine whether aquatic life is impacted by elevated sediment loads, MDE's BSID methodology was applied. The primary goal of the BSID analysis is to identify the most probable cause(s) for observed biological impairments throughout MD's 8-digit watersheds (MDE 2014d).

The BSID analysis applies a case-control, risk-based, weight-of-evidence approach to identify potential causes of biological impairment. The risk-based approach estimates the strength of association between various stressors and an impaired biological community. The BSID analysis then identifies individual stressors as probable or unlikely causes of the poor biological conditions within a given watershed, and subsequently reviews ecological plausibility. Finally, the analysis concludes whether or not these individual stressors or groups of stressors are contributing to the impairment (MDE 2014d).

The primary dataset for BSID analysis includes MDDNR-MBSS Round 2 and Round 3 data (collected between 2000-2009) because it provides a broad spectrum of paired data variables, which allow for a more comprehensive stressor analysis. MDDNR-MBSS Round 1 can also be used if there is limited Round 2 and 3 data. The MBSS is a robust statewide probability-based sampling survey for assessing the biological conditions of 1st through 4th order, non-tidal streams (Klauda et al. 1998; Roth et al. 2005). It uses a fixed length (75 meter) randomly selected stream segment for collecting site level information within a primary sampling unit (PSU), also defined as a watershed. The randomly selected stream segments, from which field data are collected, are selected using either stratified random sampling with proportional allocation, or simple random sampling (Cochran 1977). The random sample design allows for unbiased estimates of overall watershed conditions. Thus, the dataset facilitated case-control analyses because: 1) in-stream biological data are paired with chemical, physical, and land-use data variables that could be identified as possible stressors; and 2) it uses a probabilistic statewide monitoring design.

The BSID analysis combines the individual stressors (physical and chemical variables) into three generalized parameter groups in order to assess how the resulting impacts of these stressors can alter the biological community and structure. The three generalized parameter groups include: sediment, habitat, and water chemistry. Identification of a sediment stressor as contributing to the biological impairment is based on the results of the individual stressor associations within the sediment parameter grouping, which reveal the effects of sediment related impacts on stream biota (MDE 2014d).

South River Watershed Monitoring Stations

A total of 12 water quality monitoring stations were used to characterize the South River watershed for the purpose of this TMDL. The biological assessment was based on the combined results of MBSS Round 1 and Round 2 data, which includes ten stations. The BSID analysis used stations from MBSS Round 2 and Round 3, which includes eight stations. All stations are listed in Table 6 and presented in Figure 4.

Table 6: Monitoring Stations in the South River Watershed

Site Number	Sponsor	Site Type	Location	Latitude (decimal degrees)	Longitude (decimal degrees)
AA-N-072-103-97	DNR	MBSS Round 1	Tarnans Branch	38.9694	-76.6327
AA-N-075-122-97	DNR	MBSS Round 1	Bacon Ridge Branch, unnamed tributary	39.0423	-76.6261
AA-N-250-217-97	DNR	MBSS Round 1	North River	38.9973	-76.6341
AA-N-278-109-97	DNR	MBSS Round 1	Bacon Ridge Branch	39.0421	-76.6434
SOUT-101-R-2002	DNR	MBSS Round 2	South River, unnamed tributary	38.9695	-76.6086
SOUT-103-R-2002	DNR	MBSS Round 2	Flat Creek	38.9305	-76.6260
SOUT-105-R-2002	DNR	MBSS Round 2	Bell Branch, unnamed tributary	38.9886	-76.6645
SOUT-106-R-2002	DNR	MBSS Round 2	South River, unnamed tributary	38.9594	-76.6207
SOUT-108-R-2002	DNR	MBSS Round 2	Tarnans Branch	38.9798	-76.6178
SOUT-109-R-2002	DNR	MBSS Round 2	Flat Creek	38.9336	-76.6236
SOUT-101-R-2008	DNR	MBSS Round 3	Flat Creek, unnamed tributary	38.9491	-76.6220
SOUT-103-R-2008	DNR	MBSS Round 3	Bacon Ridge Branch, unnamed tributary	39.0155	-76.6143

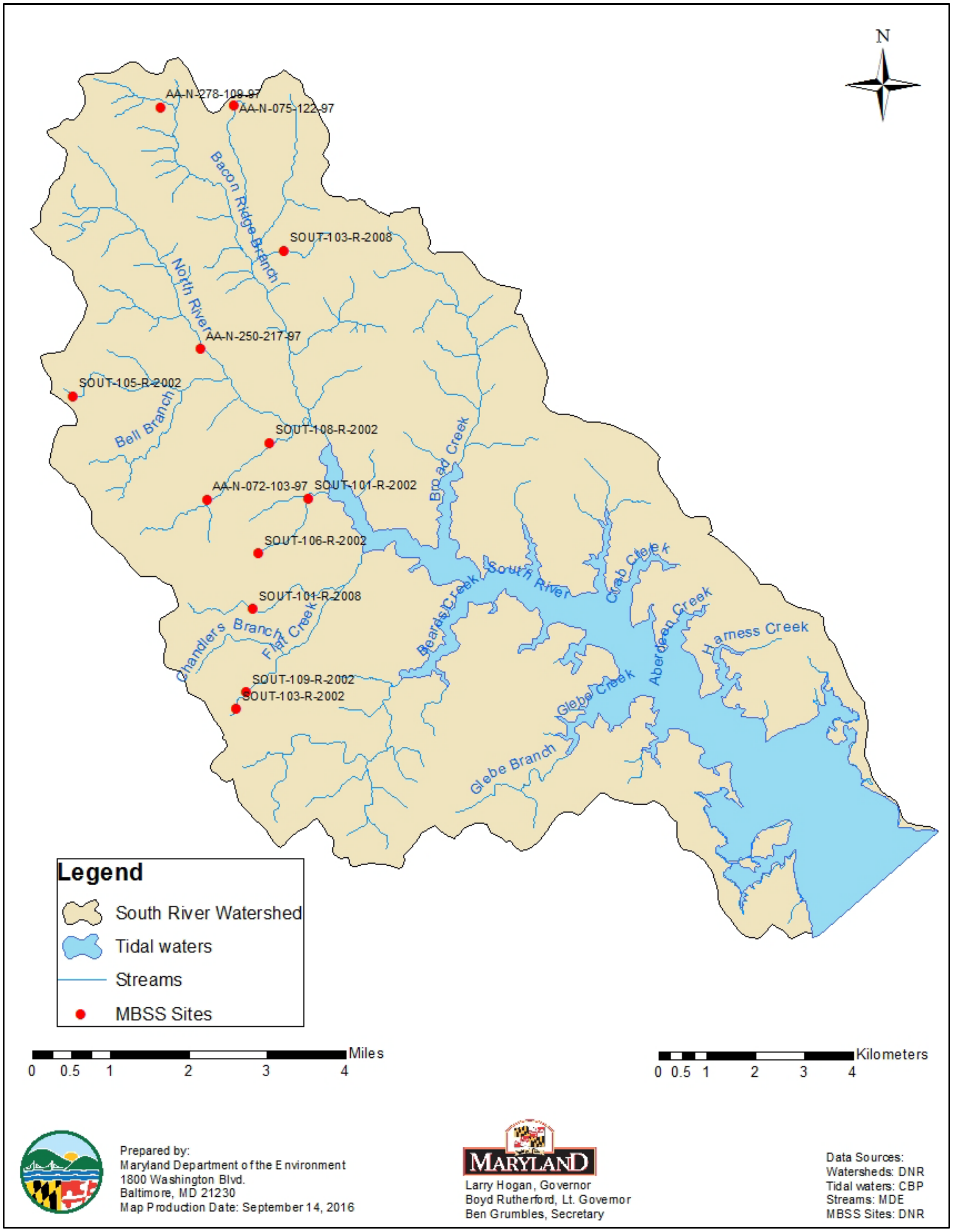

Figure 4: Monitoring Stations in the South River Watershed

2.4 Water Quality Impairment

The Maryland Surface Water Use Designation in the Code of Maryland Regulations (COMAR) for the South River watershed's non-tidal streams are designated as Use Class I - *water contact recreation, and protection of nontidal warmwater aquatic life.* All of the tidal waters and the South River mainstem are designated Use Class II - *support of estuarine and marine aquatic life and shellfish harvesting* (COMAR 2016a, b, c).

The water quality impairment of the South River watershed addressed by this TMDL is caused by an elevated sediment load beyond a level that the watershed can sustain; thereby causing sediment related impacts that cannot support aquatic life. Assessment of aquatic life is based on BIBI and FIBI scores, as demonstrated via the BSID analysis for the watershed.

The South River watershed was originally listed on Maryland's 2002 Integrated Report as impaired for impacts to biological communities. The biological assessment was based on the combined results of MBSS Round 1 (1995-1997) and Round 2 (2000-2004) data, which included ten stations. Eight of the ten stations, or 80% of the stream miles in the watershed, were assessed as having BIBI and/or FIBI scores significantly lower than 3.0 (on a scale of 1 to 5) (MDE 2012c). See Figure 4 and Table 6 for station locations and information.

The results of the BSID analysis for the South River watershed are presented in a report entitled *Watershed Report for Biological Impairment of the Non-Tidal South River Watershed in Anne Arundel County, Maryland Biological Stressor Identification Analysis Results and Interpretation*. The report states that the degradation of biological communities in the South River watershed is strongly associated with anthropogenic impacts, poor epifaunal substrate, marginal to poor and poor instream habitat structure, no riparian buffer, high chlorides, and low lab pH. (MDE 2014b).

The BSID analysis determined that the biological impairment in the South River watershed is due in part to stressors within the sediment and instream habitat parameter groupings. Overall, stressors within the sediment parameter grouping were identified as having a statistically significant association with impaired biological communities at approximately 54% of the sites with BIBI and/or FIBI scores significantly less than 3.0 throughout the watershed (MDE 2014b). Therefore, since sediment is identified as a stressor to the biological communities in the South River watershed, the watershed has been listed as impaired by sediment in the Integrated Report, and a TMDL is required.

3.0 TARGETED WATER QUALITY GOAL

The objective of the sediment TMDL established herein is to reduce sediment loads, and their detrimental, negative effects on aquatic life in the South River watershed, to levels that support the Use Class I designation for the watershed.
The CWA requires TMDLs to be protective of all the designated uses applicable to a particular waterbody. The primary focus of this TMDL is the designated use of protection of aquatic life because the Integrated Report listing was based on a biological assessment of the watershed. However, the required reductions are expected to protect all designated uses of the watershed, including water contact recreation. It is understood that aquatic life is more sensitive to sediment impacts than recreation because aquatic life impacts result from continuous exposure than can affect respiration and propagation. Recreation, on the other hand, is sporadic and often avoided during times when sediment concentrations are likely to be highest (e.g. rainstorms). Sediment also poses no human health risk due to dermal contact or minimal ingestion that could occur during recreation.
Excessive sediment has been identified by the USEPA as the leading cause of impairment of our nation’s waters, and as contributing to the decline of populations of aquatic life in North America (USEPA 2003a). Suspended sediment in streams may reduce visibility, preventing fish from seeing their prey, and may clog gills and filter feeding mechanisms of fish and benthic (bottom-dwelling) organisms. Excessive deposition of sediment on streambeds may bury eggs or larvae of fish and benthic macroinvertebrates, or degrade habitat by clogging the interstitial spaces between sand and gravel particles.

Reductions in sediment loads are expected to result from decreased watershed erosion, which will then lead to improved benthic and fish habitat conditions. Specifically, sediment load reductions are expected to result in an increase in the number of benthic sensitive species present, an increase in the available and suitable habitat for a benthic community, a possible decrease in fine sediment (fines), and improved stream habitat diversity, all of which will result in improved water quality.

The TMDL, however, will not completely resolve the impairment to biological communities within the watershed. Since the BSID watershed analysis also identifies inorganic pollutants as possible stressors impacting the biological conditions, additional TMDL or TMDLs may be needed to address the impacts to biological communities. This impairment to aquatic life will only be fully addressed when all impairing substances identified as impacting biological communities in the watershed are reduced to levels that will meet water quality standards, as established in future TMDLs for those substances (MDE 2014a, 2014c).

4.0 TOTAL MAXIMUM DAILY LOADS AND SOURCE ALLOCATION

4.1 Overview

This section describes how the sediment TMDL and the corresponding allocations were developed for the South River watershed.

4.2 Analysis Framework

Since there are no specific numeric criteria in Maryland that quantify the impact of sediment on the aquatic life of non-tidal stream systems, a reference watershed approach was used to establish the TMDL. In order to use a reference watershed approach, sediment loads must be estimated using a watershed model. For this analysis, the CBP P5.3.2 model was used to calculate the sediment loads used in the reference watershed approach.

Watershed Model

The CBP P5.3.2 watershed model was chosen to estimate the sediment loads for the South River watershed TMDL and the loads were expressed as EOS sediment loads. The spatial domain of the CBP P5.3.2 watershed model segmentation aggregates to the MD 8-digit watersheds, which is the scale of the impairment listing. The nonpoint source baseline sediment loads generated within the South River watershed are based on the EOS loads from the CBP P5.3.2 watershed model 2009 Progress Scenario. CBP P5.3.2 Progress Scenario EOS loads are calculated as the sum of individual land-use EOS loads within the watershed and represent a long-term average loading rate. Individual land-use EOS loads are calculated within the CBP P5.3.2 watershed model as a product of the land-use area, land-use target EOF loading rate, and loss from the EOF to the main channel. BMP data and reduction efficiencies are then subsequently applied to produce the final EOS loads. The loss from the EOF to the main channel is the *sediment delivery factor* and is defined as the ratio of the sediment load reaching a basin outlet to the total erosion within the basin. A *sediment delivery factor* is estimated for each land-use type based on the proximity of the land-use to the main channel. Thus, as the distance to the main channel increases, more sediment is stored within the watershed (i.e., *sediment delivery factor* decreases). Details of the data sources for the unit loading rates can be found in Section 2.2 of this report.

Reference Watershed Approach

In order to quantify the impact of sediment on the aquatic life of non-tidal stream systems, a reference watershed TMDL approach was used to establish a *sediment loading threshold* (MDE 2006). Reference watersheds were determined based on Maryland's biological assessment methodology. The biological assessment methodology assesses biological impairment at the watershed scale based on the percentage of MBSS monitoring stations, translated into watershed stream miles, that have BIBI and/or FIBI scores lower than the Minimum Allowable IBI Limit (MAL). The MAL represents the threshold under which a watershed is listed as impaired for biology and is calculated based on the average annual allowable IBI value of 3.0 (on a scale of 1 to 5), the coefficient of variation of annual sentinel site results, and an assumed normal distribution. It accounts for annual variability and helps to avoid classification errors (i.e., false positives) when assessing for biological impairments (Roth *et al*. 1998, 2000; Stribling *et al*. 1998; MDE 2014c).

Comparison of sediment loads from impaired watersheds to loads from reference watersheds requires that the watersheds be similar in physical and hydrological characteristics. To satisfy this requirement, MDE (2006) selected reference watersheds only from the Highland and Piedmont physiographic regions. This region is consistent with the non-coastal region that was identified in the 1998 development of FIBI and subsequently used in the development of BIBI (Roth *et al*. 1998; Stribling *et al*. 1998).

For the establishment of this specific TMDL, however, since the South River watershed lies almost completely within the Coastal Plain geologic province, reference watersheds, were selected from the nontidal Coastal Plain region, rather than the Piedmont and Highland Region (see appendix A for the list of reference watersheds). The same methodology used for the selection of the Highland and Piedmont reference watersheds was used to select the Coastal Plain reference watersheds. Furthermore, all subsequent methodologies used to establish the TMDL end point, based on these reference watersheds, are exactly the same as those described in MDE 2006.

To further reduce the effect of the variability within the Coastal Plain physiographic regions (i.e., soils, slope, etc.), the watershed sediment loads were then normalized by a constant background condition, the all forested watershed condition. This new normalized term, defined as the *forest normalized sediment load* (Y_n), represents how many times greater the baseline watershed sediment load is than the *all forested sediment load* (y_{for}). The y_{for} is a modeled simulation of what the sediment load would be if the watershed were in its natural all forested state, instead of its current mixed land use. It is calculated using the CBP P5.3.2 model. The *forest normalized sediment load* for this TMDL is calculated as the current watershed sediment load divided by the *all forested sediment load*. The equation for the *forest normalized sediment load* is as follows:

$$Y_n = \frac{y_{ws}}{y_{for}} \qquad \text{(Equation 4.1)}$$

Where:

Y_n = forest normalized sediment load
y_{ws} = current watershed sediment load (ton/yr)
y_{for} = all forested sediment load (ton/yr)

Seven reference watersheds were identified in the Coastal Plain physiographic region. Reference watershed *forest normalized sediment loads* were calculated using CBP P5.3.2 watershed model 2009 Progress Scenario EOS loads. The median (50^{th} percentile) and 75^{th} percentile of the reference watershed *forest normalized sediment loads* were calculated and found to be 3.9 and 4.5 respectively.[2] The median value of 3.9 was used as an environmentally conservative approach for establishing the sediment loading threshold for the TMDL (see Appendix A for more details).

The *forest normalized sediment load* for the South River watershed, estimated as 5.0, was calculated using CBP P5.3.2 2009 Progress Scenario EOS loads, to best represent current conditions. (See Calculation 4.1) A comparison of the South River watershed *forest normalized sediment load* to the *sediment loading threshold* demonstrates that the watershed exceeds the *sediment loading threshold*, indicating that it is receiving loads above the maximum allowable load that it can sustain and still meet water quality standards.

$$Y_n = \frac{y_{ws}}{y_{for}} = \frac{1{,}982\ ton/yr}{396\ ton/yr} = 5.0 \qquad \text{(Calculation 4.1)}$$

4.3 Scenario Descriptions and Results

The following analyses compare baseline conditions in the watershed (under which water quality problems exist) with potential future conditions, which project the water quality response to various simulated sediment load reductions. The analyses are grouped according to baseline conditions and future conditions associated with TMDLs.

Baseline Conditions

The baseline conditions are intended to provide a point of reference by which to compare the future scenario that simulates conditions of a TMDL. The baseline conditions typically reflect an approximation of nonpoint source loads and any upstream loads

[2] The 75^{th} percentile value of reference condition streams was recommended by EPA to be used in establishing numerical criteria (MDE 2006). The median was found, for the sediment reference watersheds, to be the approximate equivalent to other more complex statistical analyses and was used for ease of calculation (MDE 2009). Both of these values ensure that the selected threshold will represent the reference group values, with the median being more conservative (lower).

during the monitoring time frame, as well as estimated point source loads based on discharge data for the same period.

The South River watershed baseline nonpoint source sediment loads are estimated using the land-use and EOS sediment loading rates from the CBP P5.3.2 2009 Progress Scenario. The 2009 Progress Scenario was chosen because it is used as the baseline year in the Chesapeake Bay TMDL. The 2009 Progress Scenario represents 2009 land-use and BMP implementation simulated using precipitation and other meteorological inputs from the period 1990-2000 to represent variable hydrological conditions, thereby addressing annual changes in hydrology and capturing wet, average and dry years. The period 1991-2000 is the hydrological simulation period for the Chesapeake Bay TMDL.

The point source sediment loads are estimated based on the NPDES permit information. Details of these loading source estimates can be found in Section 2.2 and the technical memorandum to this document entitled *Point Sources of Sediment in the South River Watershed*.

<u>TMDL Conditions</u>

The TMDL scenario simulates conditions under which sediment loads have been reduced to levels that support aquatic life. In the TMDL calculation, the allowable load for the impaired watershed is calculated as the product of the *sediment loading threshold* (determined from watersheds with a healthy biological community) and the South River watershed *all forested sediment load* (see Section 4.2). The resulting load is considered the maximum allowable load the watershed can sustain and support aquatic life.

The TMDL loading and associated reductions are averaged at the watershed scale, however, it is important to recognize that some subwatersheds may require higher reductions than others, depending on the distribution of the land-use.

The formula for estimating the TMDL is as follows:

$$TMDL = \sum_{i=1}^{n} Yn_{ref} \cdot y_{forest_i} \qquad \text{(Equation 4.2)}$$

Where:
TMDL = allowable load for impaired watershed (ton/yr)
Yn_{ref} = sediment loading threshold
y_{forest_i} = all forested sediment load for CBP P5.3.2 model segment *i* (ton/yr)
i = CBP P5.3.2 model segment
n = number of CBP P5.3.2 model segments in watershed

The South River watershed allowable sediment load is estimated using Equation 4.2.

4.4 Critical Condition and Seasonality

USEPA's regulations require TMDLs to take into account seasonality and critical conditions for stream flow, loading, and water quality parameters (CFR 2012b). The intent of this requirement is to ensure that the water quality of the waterbody is protected during times when it is most vulnerable. The biological monitoring data used to determine the reference watersheds reflect the impacts of stressors (i.e., sediment impacts to stream biota) over the course of time and therefore depict an average stream condition (i.e., captures all high and low flow events). Since the TMDL endpoint is based on the forest normalized loads from watersheds assessed as having good biological conditions (i.e., passing Maryland's biological assessment), by the nature of the biological data described above, it must inherently include the critical conditions of the reference watersheds. Therefore, since the TMDL reduces the watershed sediment load to a level compatible with that of the reference watersheds, critical conditions are inherently addressed. Moreover, the sediment loading rates used in the TMDL were determined using the CBP P5.3.2 model, which is a continuous simulation model with a simulation period 1991-2000, based on Hydrological Simulation Program Fortran (HSPF) model, thereby addressing annual changes in hydrology and capturing wet, average, and dry years.

Seasonality is captured in two components. First, it is implicitly included through the use of the biological monitoring data as this data reflects the impacts of stressors over time, as described above. Second, the MBSS dataset included benthic sampling in the spring (March 1 - April 30) and fish sampling in the summer (June 1 - September 30). Benthic sampling in the spring allows for the most accurate assessment of the benthic population, and therefore provides an excellent means of assessing the anthropogenic effects of sediment impacts on the benthic community. Fish sampling is conducted in the summer when low flow conditions significantly limit the physical habitat of the fish community, and it is therefore most reflective of the effects of anthropogenic stressors as well.

4.5 TMDL Loading Caps

This section presents the South River watershed average annual sediment TMDL. This load is considered the maximum allowable long-term average annual load the watershed can sustain and support aquatic life.

The long-term average annual TMDL was calculated for the South River watershed based on Equation 4.2 and set at a load 3.9 times the all forested condition of the watershed. In order to attain the TMDL loading cap calculated for the watershed, reductions were applied to the predominant sediment sources (i.e., significant contributors of sediment to the stream system), independent of jurisdiction. Sediment reductions are also required in the South River watershed to meet the sediment allocations assigned under the 2010 Chesapeake Bay TMDL for sediment in the South River Mesohaline Water Quality Segment. To ensure consistency with the Bay TMDL, and therefore efficiency in the reduction of sediment loads, reductions will be applied to the same sediment sources identified in Maryland's Watershed Implementation Plans (WIPs) for the 2010 Bay

TMDL, as applicable in the watershed. These include: (1) regulated developed land; (2) conventional till crops, conservation till crops, hay, and pasture; (3) harvested forest; (4) unregulated animal feeding operations and concentrated animal feeding operations (CAFOs); and (5) industrial wastewater sources and municipal wastewater treatment plants. Forest land is not assigned reductions because it is considered the most natural condition in the watershed.

The South River Watershed Baseline Load and TMDL are presented in Table 7.

Table 7: South River Watershed Baseline Load and TMDL

Baseline Load (ton/yr)	TMDL (ton/yr)	Total Reduction (%)
1,982	1,546	22

4.6 Load Allocations Between Point and Nonpoint Sources

Per USEPA regulation, all TMDLs need to be presented as a sum of Wasteload Allocations (WLAs) for point sources and Load Allocations (LAs) for nonpoint source loads generated within the assessment unit, accounting for natural background, tributary, and adjacent segment loads (CFR 2012a). The State reserves the right to allocate the TMDL among different sources in any manner that protects aquatic life from sediment related impacts.

Load Allocation
Individual LAs for each nonpoint land-use sector were calculated using the allocation methodology in the MD Phase I WIP, which was designed to be equitable, effective, and consistent with water quality standards. (MDE 2010) The allocations were calculated by applying equal reductions to the *reducible* loads of all sectors. The *reducible* load is defined as the difference between the No Action (NA) scenario and the "Everything, Everyone, Everywhere" (E3) scenario. The NA scenario represents current land-uses without any sediment controls applied, while the E3 scenario represents the application of all possible BMPs and control technologies to current land-use. For more detailed information regarding the calculation of the LA, please see "*Maryland's Phase I Watershed Implementation Plan for the Chesapeake Bay Total Maximum Daily Load.*"

In the South River watershed, harvested forest, crops, pasture, and nurseries were identified as predominant nonpoint sources of sediment. Other land uses that contributed less than 1% of the total load were not reduced as they would produce no discernible reductions. Forest is not assigned reductions, as it represents the most natural condition in the watershed. Sediment loads from urban lands are regulated under National Pollutant Discharge Elimination System (NPDES) permits and are considered point source loads that must be included in the Waste Load Allocation (WLA) portion of a TMDL (US EPA 2002).

In this document, the LA for the South River watershed is expressed as one aggregate value for all nonpoint sources. For more detailed information regarding the South River watershed TMDL nonpoint source LA, please see the technical memorandum to this document entitled *Nonpoint Sources of Sediment in the South River Watershed.*

A summary of the baseline and load allocation for nonpoint sources is presented in Table 8. The percent reduction shown in Table 8 does not represent the reduction applied to reducible loads, but the required reduction between the allocation and the baseline load.

Table 8: South River Watershed TMDL Reductions by Source Category

	Baseline Load Source Categories		Baseline Load (ton/yr)	TMDL Components	TMDL (ton/yr)	Reduction (%)
South River Watershed Contribution	**Nonpoint Source**		537	**LA**	495	8
	Point Source	Urban Stormwater	1,444	**WLA**	1,050	27
		Waste Water	1		1	0
Total			**1,982**		**1,546**	**22**

Wasteload Allocation
The WLA of the South River watershed is allocated to two permitted source categories, the Waste Water WLA and the Stormwater WLA. The categories are described below.

<u>Waste Water WLA</u>

Waste Water permits with specific TSS limits and corresponding flow information are assigned to the WLA. In this case, detailed information is available to accurately estimate the WLA. If specific TSS limits are not explicitly stated in the waste water permit, then TSS loads are expected to be *de minimis*. Facilities that have permits without specific TSS limits that are considered *de minimis* are not included in the TMDL.

Waste Water permits with specific TSS limits include:

- Individual industrial facilities
- Individual municipal facilities
- General mineral mining facilities

There is one minor municipal waste water source with explicit TSS limits in the South River watershed that contributes to the watershed sediment load. There are no industrial or general mining facilities with permits regulating their discharge of sediment in the watershed. The total estimated TSS load from this source is based on current, average permit limits and is equal to 1 ton/yr. As mentioned above, no reduction was applied to this source, since such controls would produce no discernible water quality benefit when nonpoint sources and regulated stormwater sources comprise greater than 99% of the total watershed sediment load. For more detailed information on the wastewater permits, please see the technical memorandum entitled *Point Sources of Sediment in the South River Watershed*.

Stormwater WLA

Per USEPA requirements, "stormwater discharges that are regulated under Phase I or Phase II of the NPDES stormwater program are point sources that must be included in the WLA portion of a TMDL" (USEPA 2002). Phase I and II permits can include the following types of discharges:

- Small, medium, and large municipal separate storm sewer systems (MS4s) – these can be owned by local jurisdictions, municipalities, and state and federal entities (e.g., departments of transportation, hospitals, military bases),
- Industrial facilities permitted for stormwater discharges, and
- Small and large construction sites.

USEPA recognizes that available data and information are usually not detailed enough to determine WLAs for NPDES regulated stormwater discharges on an outfall-specific basis (USEPA 2002). Therefore, NPDES regulated stormwater loads within the South River watershed TMDL will be expressed as an aggregate NPDES Stormwater WLA. Upon approval of the TMDL, "NPDES-regulated municipal stormwater and small construction stormwater discharges effluent limits should be expressed as BMPs or other similar requirements, rather than as numeric effluent limits" (USEPA 2002).

The South River NPDES Stormwater WLA is based on reductions applied to the sediment load from the portion of the urban land-use in the watershed associated with the applicable NPDES regulated stormwater permits. The WLA may include legacy or other sediment sources. Some of these sources may also be subject to controls from other management programs. The South River NPDES Stormwater WLA requires an overall reduction of 27% (see Table 8).

As stormwater assessment and/or other program monitoring efforts result in a more refined source assessment, MDE reserves the right to revise the current NPDES Stormwater WLA provided the revisions protect aquatic life from sediment related impacts.

For more information on the methods used to calculate the NPDES regulated stormwater baseline sediment load, see Section 2.2.2. For a detailed list of all of the NPDES regulated stormwater discharges within the watershed and information regarding the NPDES stormwater WLA distribution amongst these discharges, please see the technical memorandum to this document entitled *Point Sources of Sediment in the South River Watershed.*

4.7 Margin of Safety

All TMDLs must include a margin of safety (MOS) to account for any lack of knowledge and uncertainty concerning the relationship between loads and water quality (CFR 2012b). The MOS shall also account for any rounding errors generated in the various calculations used in the development of the TMDL. This TMDL was developed using an environmentally conservative approach that implicitly incorporates an MOS. Specifically, as was described in Section 4.2, the reference watershed forest normalized EOS loads were chosen in a conservative manner. Analysis of the reference group *forest normalized sediment loads* indicates that the 75^{th} percentile of the reference watersheds is a value of 4.5 and that the median value is 3.9. Achieving a 75^{th} percentile forest normalized sediment load would assure that the watershed falls within the range of unimpaired watersheds. However, for this analysis, the *sediment loading threshold* was set at the median value of 3.9 (MDE 2006). Use of the median as the threshold creates an environmentally conservative estimate, and results in an implicit MOS.

4.8 Summary of Total Maximum Daily Loads

The average annual non-tidal South River watershed TMDL is summarized in Table 9. The TMDL is the sum of the LA, NPDES Stormwater WLA, Waste Water WLA, and MOS. The attainment of water quality standards within the non-tidal South River watershed can only be achieved by meeting the average annual TMDL of sediment/TSS specified for the watershed within this report. The Maximum Daily Load (MDL) is summarized in Table 10 (See Appendix B for more details).

Table 9: South River Watershed Average Annual TMDL of Sediment/TSS (ton/yr)

TMDL (ton/yr)	=	LA_{SR}	+	NPDES Stormwater WLA_{SR}	+	Waste Water WLA_{SR}	+	MOS
1,546	=	495	+	1,050	+	1	+	Implicit

Table 10: South River Watershed Maximum Daily Load of Sediment/TSS (ton/day)

MDL (ton/day)	=	LA_{SR}	+	NPDES Stormwater WLA_{SR}	+	Waste Water WLA_{SR}	+	MOS
13.3	=	4.2	+	9.1	+	negligible	+	Implicit

5.0 ASSURANCE OF IMPLEMENTATION

Section 303(d) of the CWA and current USEPA regulations require reasonable assurance that the sediment TMDL can and will be implemented (CFR 2012b). This section provides the basis for reasonable assurance that the sediment TMDL in the South River watershed will be achieved and maintained.

While this TMDL establishes a sediment loading target for the watershed, watershed managers and other stakeholders should always remain cognizant that the endpoint of this TMDL, and hence the definition of its successful implementation, is based on in-stream biological health. Load reductions are critical to tracking this effort, since the TMDL target is defined as the point where sediment loads match those seen in reference watersheds, but the watershed cannot be delisted or classified as meeting water quality standards until it is demonstrated that the biological health of the stream system is no longer impaired by sediment. In planning any implementation efforts related to this TMDL, careful consideration should be given both to the sediment load reductions, and to the direct potential impacts on biological communities. A practice that removes a modest load of TSS, but does not disturb aquatic life in the short-term, might provide more benefit to the watershed than one with the higher TSS removal potential, but with the potential to adversely impact existing aquatic life.

2010 Chesapeake Bay TMDLs

Implementation of the TMDL for sediment in the South River watershed is expected to occur in parallel with implementation efforts for the 2010 Chesapeake Bay TMDLs for nutrients and sediment in the mesohaline South River. While the objectives of the two efforts differ, with the 2010 Bay TMDLs focused on tidal water quality and this TMDL targeting biological integrity in non-tidal streams, many of the sediment reductions achieved through implementation activities should result in progress toward both goals.

The strategies for implementing the 2010 Bay TMDLs are described in Maryland's Phase I WIP (MDE 2010) and Phase II WIP (MDE 2012). The WIPs are the centerpieces of the State's "reasonable assurance" of implementation for the 2010 Bay TMDLs, and the strategies encompass a host of BMPs, pollution controls and other actions for all source sectors that cumulatively will result in meeting the State's 2025 targets, as verified by the Chesapeake Bay Water Quality Sediment Transport Model. In particular, the implementation of practices to reduce sediment loadings from the agricultural and urban stormwater sectors should result in decreased loads in the South River watershed's non-tidal streams.

MS4 Permit Implementation Plans

MDE published the Final Determination to Issue Stormwater Permit to Anne Arundel County in February 2014. The permit states, *"By regulation at 40 CFR §122.44, BMPs and programs implemented pursuant to this permit must be consistent with applicable WLAs developed under [US]EPA approved TMDLs."*

Section IV.E. of the permit details requirements for *Restoration Plans and Total Maximum Daily Loads*. Within one year of permit issuance, the County is required to submit an implementation plan for each stormwater WLA approved by USEPA prior to the effective date of the permit. For TMDLs approved after the permit, implementation plans are due within one year of USEPA approval of the TMDL. Implementation plans should include the following: a detailed implementation schedule, the final date for meeting applicable WLAs, a detailed cost estimate for all elements of the plan, a system that evaluates and tracks implementation through monitoring or modeling to document progress towards meeting established benchmarks, deadlines, and stormwater WLAs, and a public participation program. An annual TMDL assessment report shall also be submitted to MDE. Many of the practices which are described in the permittees' stormwater WLA implementation plans may also be used by the permittees as retrofits for meeting their impervious area restoration requirements.

Stormwater retrofits can address both water quality and quantity. Examples of these retrofits include the reduction of impervious surfaces, modification of existing or installation of new stormwater structural practices, increased urban tree canopy, and stream restoration projects. Based on estimates by CBP, stormwater retrofit reductions range from as low as 10% for dry detention, to approximately 80% for wet ponds, wetlands, infiltration practices, and filtering practices (USEPA 2003b).

For more information on the MS4 permits, please see Maryland's NPDES Municipal Separate Storm Sewer System (MS4) Permits.

Implementation of Agricultural Best Management Practices

In agricultural areas comprehensive soil conservation plans can be developed that meet criteria of the USDA-NRCS Field Office Technical Guide (USDA 1983). Soil conservation plans help control erosion by modifying cultural practices or structural practices. The reduction percentage attributed to cultural practices is determined based on changes in land-use, while structural practices have a reduction percentage of up to 25%. In addition, sediment loadings from livestock can be controlled via stream fencing and rotational grazing. Sediment reduction efficiencies of methods applicable to pasture land-use range from 40% to 75% (USEPA 2004). Lastly, riparian buffers can reduce the effect of agricultural sediment sources through trapping and filtering.

Maryland Funding Programs

In response to the WIP and the increased responsibility for local governments to achieve nutrient and sediment reduction goals, Maryland has continued to increase funding in the Chesapeake and Atlantic Coastal Bays Trust Fund. According to the FFY2015 Section 40 Report, even though the annual restoration funds for the four agencies (MDDNR, MDA, MDE, MDP) varies from year to year, the total restoration funds for the first three years of the Chesapeake Bay WIP implementation evaluated time period (FY10 – FY12) was $882,327,165, while the total for the past four years of the period (FY12 – FY15) was $2,383,507,560, an increase of 170 percent. This increase was driven in part by the two primary Bay restoration Special Funds: The Bay Restoration Fund and the Chesapeake and Atlantic Coastal Bays Trust Fund (MDE *et al*., 2016). For more information on Maryland's implementation and funding strategies to achieve nutrient and sediment reductions throughout the State's portion of the Chesapeake Bay watershed, please see Maryland's Phase II Watershed Implementation Plan.

Some other examples of programs that can provide funding for local governments and agricultural sources include the Federal Nonpoint Source Management Program (§ 319 of the Clean Water Act), the Buffer Incentive Program (BIP), the State Water Quality Revolving Loan Fund and the Maryland Agricultural Water Quality Cost-Share Program.

In summary, through the use of the aforementioned funding mechanisms and BMPs, there is reasonable assurance that this TMDL can be implemented.

Additional Biological Stressors

As has been stated previously in this report, the biological impairment in this watershed is due to multiple stressors, not just sediment. While reducing TSS might bring about a water quality impact in terms of clarity, achieving a positive impact in stream biological communities might require several stressors to be addressed. These stressors were described in the South River BSID report.

The BSID identified chlorides as chemical stressors significantly associated with degraded biological conditions in this watershed. This was listed as an impairment on Category 5 of the 2014 Integrated Report, and will require a TMDL. Furthermore, the BSID identified inadequate riparian buffer zones as another likely cause of degraded biological communities. Based on the report's recommendation, inadequate riparian buffer zones in this watershed was included on the listing of impaired waters as Category 4c, a list that covers water body impairments that are not caused by a pollutant.

The report also details specific substressors, poor epifaunal substrate, within the larger sediment stressor class that is associated with biological degradation. Within the in-stream habitat stressor class, the report identifies marginal and poor in-stream habitat as stressors.

Many of the implementation actions to address sediment could concurrently address the other stressors identified in the BSID report. For example, a stream restoration project that reduces sediment loads could improve epifaunal substrate and in-stream habitat. Since biological improvements will likely only be seen when multiple structural and pollutant stressors are addressed, watershed managers developing plans to address sediment should consider the effect of restoration projects on other stressors. Where possible, preference should be given to designs that address multiple stressors.

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APPENDIX A – Watershed Characterization Data

Table A-1: Reference Watersheds

MD 8-Name	MD 8-digit	Percent Stream Mile BIBI/FIBI < 3.0 (%)[1,2]	Forest Normalized Sediment Load[3]
Potomac River - Middle Tidal	02140102	14.3	2.46
Breton Bay	02140104	16.7	3.81
St. Clements Bay	02140105	16.7	4.30
Wicomico River	02140106	20.0	4.80
Gilbert Swamp	02140107	17.6	4.72
Zekiah Swamp	02140108	14.3	3.91
Nanjemoy Creek	02140110	17.6	2.88
Median			**3.9**
75th percentile			**4.5**

Notes: [1] Percent stream mile is based on the percentage of MBSS stations with BIBI and/or FIBI scores significantly lower than 3.0 within the watershed (MDE 2012a).
[2] The threshold to determine if an 8-digit watershed is impaired for impacts to biological communities (IBI<3.0), is based on a comparison to reference conditions (MDE 2014c).
[3] Forest normalized sediment loads based on Maryland watershed area only (consistent with MBSS random monitoring data).

APPENDIX B – Technical Approach Used to Generate Maximum Daily Loads

Summary

This appendix documents the technical approach used to define maximum daily loads (MDLs) of sediment consistent with the average annual TMDL in the South River watershed, which is considered the maximum allowable load the watershed can sustain and support aquatic life. The approach builds upon the modeling analysis that was conducted to determine the sediment loadings and can be summarized as follows.

- The approach defines MDLs for each of the source categories.
- The approach builds upon the TMDL modeling analysis that was conducted to ensure that average annual loading targets are at a level that support aquatic life.
- The approach converts daily time-series loadings into TMDL values in a manner that is consistent with available USEPA guidance on generating daily loads for TMDLs (USEPA 2007).
- The approach considers a daily load level of a resolution based on the specific data that exists for each source category.

Introduction

This appendix documents the development and application of the approach used to define MDL values. It is divided into sections discussing:

- Basis for approach
- Options considered
- Selected approach
- Results of approach

Basis for approach

The overall approach for the development of daily loads was based upon the following factors:

- **Average Annual TMDL:** The basis of the average annual sediment TMDL is that cumulative high sediment loading rates have negative impacts on the biological community. Thus, the average annual sediment load was calculated so as to ensure the support of aquatic life.
- **CBP P5.3.2 Watershed Model Sediment Loads:** As described in Section 2.2, the nonpoint source sediment loads from the South River watershed are based on EOS loads from the CBP P5.3.2 watershed model. The CBP P5.3.2 model river segments were calibrated to daily monitoring information for watersheds with a flow greater than 100 cubic feet per second (cfs), or an approximate area of 100 square miles.

- **Draft USEPA guidance document entitled "Developing Daily Loads for Load-based TMDLs":** This guidance document provides options for defining MDLs when using TMDL approaches that generate daily output (USEPA 2007).

The rationale for developing TMDLs expressed as *daily* loads was to accept the existing average annual TMDL, but then develop a method for converting this number to a MDL in a manner consistent with USEPA guidance and available information.

Options considered

The draft USEPA guidance document for developing daily loads does not specify a single approach that must be adhered to, but rather it contains a range of acceptable options (USEPA 2007). The selection of a specific method for translating a time-series of allowable loads into the expression of a TMDL requires decisions regarding both the level of resolution (e.g., single daily load for all conditions vs. loads that vary with environmental conditions) and level of probability associated with the TMDL.

This section describes the range of options that were considered when developing methods to calculate South River watershed MDLs.

<u>Level of Resolution</u>

The level of resolution pertains to the amount of detail used in specifying the MDL. The draft USEPA guidance document on daily loads provides three categories of options for level of resolution, all of which are potentially applicable for the South River watershed:

1. **Representative daily load:** In this option, a single daily load (or multiple representative daily loads) is specified that covers all time periods and environmental conditions.

2. **Variable daily load:** This option allows the MDL to vary as function of a particular characteristic that affects loading or waterbody response, such as flow or season.

<u>Probability Level</u>

All TMDLs have some probability of being exceeded, with the specific probability being either explicitly specified or implicitly assumed. This level of probability directly or indirectly reflects two separate phenomena:

1. Water quality criteria consist of components describing acceptable magnitude, duration, and frequency. The frequency component addresses how often conditions can allowably surpass the combined magnitude and duration components.
2. Pollutant loads, especially from wet weather sources, typically exhibit a large degree of variability over time. It is rarely practical to specify a "never to be exceeded value" for a daily load, as essentially any loading value has some finite probability of being exceeded.

The draft daily load guidance document states that the probability component of the MDL should be based on a representative statistical measure that is dependent upon the specific TMDL and the best professional judgment of the developers (USEPA 2007). This statistical measure represents how often the MDL is expected/allowed to be exceeded. The primary options for selecting this level of protection would be:

1. **The maximum daily load reflects some central tendency:** In this option, the MDL is based upon the mean or median value of the range of loads expected to occur. The variability in the actual loads is not addressed.
2. **The maximum daily load is a value that will be exceeded with a pre-defined probability:** In this option, a “reasonable” upper bound percentile is selected for the MDL based upon a characterization of the variability of daily loads. For example, selection of the 95^{th} percentile value would result in a MDL that would be exceeded 5% of the time.
3. **The maximum daily load reflects a level of protection implicitly provided by the selection of some “critical” period**: In this option, the MDL is based upon the allowable load that is predicted to occur during some critical period examined during the analysis. The developer does not explicitly specify the probability of occurrence.

Selected Approach

The approach selected for defining a South River Watershed MDL was based upon the specific data that exists for each source category. The approach consists of unique methods for each of the following categories of sources:

- Approach for Nonpoint Sources and Stormwater Point Sources within the South River watershed
- Approach for Waste Water Point Sources within the South River watershed

Approach for Nonpoint Sources and Stormwater Point Sources within the South River Watershed

The level of resolution selected for the South River MDL was a representative daily load, expressed as a single daily load for each loading source. This approach was chosen based upon the specific data that exists for nonpoint sources and stormwater point sources within the South River watershed. Currently, the best available data is the CBP P5.3.2 model daily time series calibrated to long-term average annual loads (per land-use). The CBP reach simulation results are calibrated to daily monitoring information for watershed segments with a flow typically greater than 100 cfs.

The probability level selected for the South River MDL was a pre-defined exceedance probability. Based on the USEPA guidance, “in the case where a long term daily load dataset is available, in which multiple years of data and a variety of environmental conditions are represented, it is preferable to select a maximum daily load as a percentile of the load distribution. A sufficiently long-term dataset allows for minimizing error associated with the fact that the daily load dataset might not exactly match a normal or lognormal distribution" (USEPA 2007). The exact percentile value to be used should be determined by the TMDL developer, based on site specific characteristics.

This CBP P5.3.2 model output provides a time series of daily TSS loads from the South River watershed, covering a 20-year period from 1985 to 2005. Because this is a long-term time series, it captures a broad range of meteorological and hydrological conditions and also minimizes the effect of potential statistical variances. As with the calculation of the TMDL value, environmentally conservative principles are also used in the MDL calculation. A 95th percentile daily load value was selected to represent the maximum of the daily times series loads, meaning that there is a 5% probability that daily loads will exceed this value. This percentile was chosen rather the 99th (which is also considered acceptable based on USEPA), in order to avoid the influence of extreme weather events and statistical outliers. Since the 95th percentile represents the maximum of the current (baseline) condition, the reduction percentage applied to the total average annual TMDL, was applied to the 95th percentile value to calculate the final total MDL value. The MDL values for the LA, NPDES Stormwater WLA, and Waste Water WLA are calculated based on the proportions they are given in the TMDL.

$$MDL = 95th\ percentile\ of\ daily\ load\ series\ values * Reduction\ \%\ from\ TMDL \quad \text{(Eq B-1)}$$

Where:
MDL = Maximum Daily Load, ton/day
Daily load series values = CBP 5.3.2 output
TMDL = Long term average annual load, ton/yr

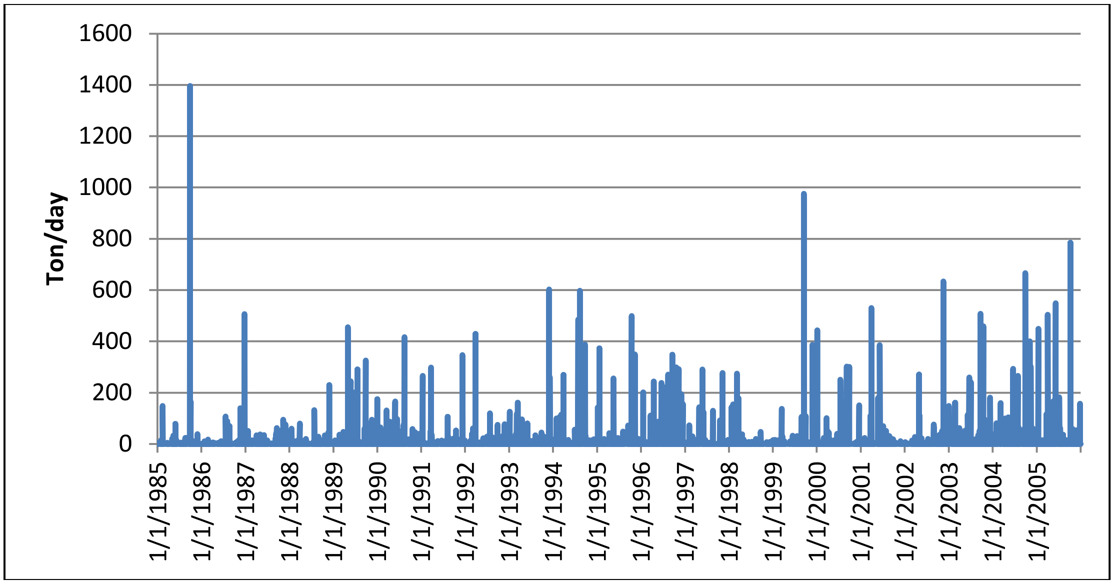

Figure B-1: Daily Time Series of CBP River Segment Daily Simulation Results for the South River Watershed

Approach for Waste Water Point Sources within the South River Watershed

The TMDL also considers contributions from other point sources (i.e., sources other than stormwater point sources) in the watershed that have NPDES permits with sediment limits. As these sources are generally minor contributors to the overall sediment load, the TMDL analysis that defined the average annual TMDL did not propose any reductions for these sources and held each of them constant at their existing technology-based NPDES permit monthly (or daily if monthly was not specified) limit for the entire year.

The approach used to determine MDLs for these sources was dependent upon whether a maximum daily limit was specified within the permit. If a maximum daily limit was specified, then the reported average flow was multiplied by the daily maximum limit and a conversion factor of 0.0042 to obtain an MDL in ton/day. If a maximum daily limit was not specified, the MDLs were calculated based on the guidance provided in the Technical Support Document (TSD) for Water Quality-based Toxics Control (USEPA 1991). The long-term average annual TMDL was converted to maximum daily limits using Table 5-2 of the TSD assuming a coefficient of variation of 0.6 and a 99^{th} percentile probability. This results in a dimensionless multiplication factor of 3.11. The average annual South River TMDL of sediment/TSS is reported in ton/yr, and the conversion from ton/yr to a MDL in ton/day is 0.0085 (e.g. 3.11/365).

Results of approach

This section lists the results of the selected approach to define the South River MDLs. The final results are presented in Table B-1.

- Calculation Approach for Nonpoint Sources and Stormwater Point Sources within the South River Watershed

The MDL for Nonpoint Sources and Stormwater Point Sources within the South River Watershed is based upon the 95th percentile value of the CBP P5.3.2 model daily load time series, reduced by the same percentage as the corresponding TMDL value. The 95th percentile load of the daily times series is 16 tons/day and with a TMDL reduction of 22%, it results in a total watershed MDL of 12.5 tons/day. The total MDL is subdivided in accordance with the same ratios present in the TMDL.

- Calculation Approach for Waste Water Point Sources within the South River Watershed
    - For permits with a daily maximum limit:

Waste Water WLA_{SR} (ton/day) = Permit flow (millions of gallons per day (MGD)) * Daily maximum permit limit (milligrams per liter (mg/l)) * 0.0042, where 0.0042 is a combined factor required to convert units to ton/day

- For permits without a daily maximum limit:

Waste Water WLA_{SR} (ton/day) = Average Annual TMDL Waste Water WLA_{SR} Other (ton/yr)* 0.0085, where 0.0085 is the factor required to convert units to ton/day

The aggregate MDL for the point sources in the watershed is negligible.

Table B-1: South River Watershed Maximum Daily Loads of Sediment/TSS (ton/day)

MDL (ton/day)	=	LA_{SR}	+	NPDES Stormwater WLA_{SR}	+	Waste Water WLA_{SR}	+	MOS
13.3	=	4.2	+	9.1	+	0.0085	+	Implicit